

# **Protected species interactions with the directed shark gillnet fishery of Florida and Georgia from 1999-2002.**

Lance Garrison  
SEFSC, Miami Laboratory

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## **Introduction:**

The directed shark gillnet fishery has been operating year round in coastal waters between southern Georgia and south Florida since approximately 1990 (Trent *et al.*, 1997), and currently consists of 6 vessels that are included in the SEFSC observer program. In general, these vessels use relatively large mesh sizes (5-10 inches), and net lengths are typically greater than 1500 feet (Trent *et al.* 1997). However, there are a large number of additional vessels using gillnet gear in coastal waters off Florida and Georgia that are not included in the observer program. The characteristics of the gear used, target species, and areas fished are poorly defined and prevents extrapolation of information in the observed shark gillnet effort to other components. Therefore, the current report focuses exclusively on bycatch mortality for the observed shark gillnet fishery.

Since 1999, the Atlantic Large Whale Take Reduction Plan restricted the activities of the fishery to waters south of 27° 51' N latitude during the Critical Right Whale season from 15 November – 31 March. Therefore, during the large coastal shark season beginning January 1, the fishing effort is concentrated south of Cape Canaveral, Florida (Figure 1), and there is very high observer coverage.

The current analysis examines observed bycatch rates, fishery behavior, and fishery effort to estimate the annual incidental capture and mortality of bottlenose dolphin (*Tursiops truncatus*), Atlantic spotted dolphin (*Stenella frontalis*), loggerhead turtles (*Caretta caretta*) and leatherback turtles (*Dermochyles coriacea*) due to the directed shark gillnet fishery between 1999-2002.

## **Methodology:**

### *Observer Data*

Since 1999, observer coverage has been very high during the critical right whale season from Nov 15 – March 31. Observer coverage has approached 100% of vessel trips during January and February (Carlson & Lee 2000, Carlson & Lee 1999, Carlson 2001, Carlson and Baremore, 2002a). Historically, there is very little observer coverage during other times of the year, however during the last 2 years there has been a significant increase in observer coverage outside of the right whale season (Carlson and Baremore, 2001; Carlson and Baremore, 2002b). The observer program uses methods that have remained standard since 1993 (see Trent *et al.*

1997, Carlson & Lee 1999). The observer is positioned forward of net reels and has an unobstructed view of the nets during haulback. The probability of a large amount of unobserved bycatch or “fall out” of incidental catch is considered low (Carlson & Lee 1999, Trent *et al.* 1997).

### *Fishery Effort*

Effort information was obtained from the NMFS fishing vessel logbook database. The first is a mandatory reporting program where vessel operators provide information on catch, effort, and gear characteristics for each fishing trip on logbook trip report forms provided by NMFS. Trip data from the logbook program were referenced by specific vessel permit numbers that are included in the shark gillnet observer program. The fishing vessel logbooks provide information on spatial distribution of the catch (by fishery statistical area, Figure 1) and limited information on gear and effort characteristics.

Shark drift gillnetting typically occurs at night, and vessels generally make one net set per fishing day. Average soak times range between 6-10 hours for each set (Trent *et al.* 1997, Carlson and Lee, 1999). Soak times are highly variable and are not well reported, and the number of sets for a given trip is not recorded in the logbooks. Therefore, the unit of effort used in this analysis is an individual fishing trip represented by a unique schedule number in the logbook data.

The spatial distribution of fishing effort is strongly driven by management considerations. During the “right whale” season from November 15-March 30, the fishery is restricted to fishing area 2780 and further south (Figure 1). Following this period, the fishing effort occurs primarily off of central Florida (primarily in fishing area 2880) and Georgia (Figure 1). The level of observer coverage also varies strongly by these seasons and areas, with very high coverage during the right whale season. In addition, a small amount of effort occurs off of Key West, Florida during the right whale season. The bycatch estimates were therefore stratified by season (right whale and non-right whale) and into 4 geographic areas: Georgia (fishing areas 3080 and 3180), Central Florida (areas 2880 and 2980), Southern Florida (areas 2780 and south), and Key West (Figure 1).

### *Mortality Estimation*

For each analytical stratum and species, the mean and variance of catch rates for bottlenose dolphin in observed trips was calculated using a delta estimator (Pennington 1993). The delta estimator is more appropriate than the simple mean because catch rates are generally log-normally distributed and bycatch events are rare. This method has been previously used to estimate bycatch rates of marine mammals and turtles in the pelagic longline fisheries (Johnson *et al.* 1999). The delta mean bycatch rate for each analytical stratum,  $t$ , is calculated as:

$$(1) \quad C_t = \frac{m_t}{n_t} e^{L_t} G(s_L^2/2),$$

where:

$m_t$  is the number of trips with observed bycatch,

$n_t$  is the total number of observed trips,

$L_t$  is the mean of the log-transformed number of animals taken where bycatch occurred.

$s_L^2$  is the observed sample variance of the log transformed bycatch rate, and

$G$  is the cumulative probability function from the Poisson distribution given as:

$$(2) \quad G(s_L^2/2) = 1 + \frac{m_t - 1}{m_t} (s_L^2/2) + \sum_{j=2}^{\infty} \frac{(m_t - 1)^{2j-1}}{m_t^j (m_t + 1)(m_t + 3) \dots (m_t + 2j - 3)} \times \frac{(s_L^2/2)^j}{j!}.$$

The series was computed numerically over  $j$  terms until meeting a convergence criterion of a change in the function value of  $< 0.0001$  with additional terms ( $j$ ). Convergence was generally achieved with  $< 10$  terms. The variance of the delta estimator is:

$$(3) \quad \text{var}(C_t) = \frac{m_t}{n_t} \left( e^{2L_t} \left[ \frac{m_t}{n_t} G^2(s_L^2/2) - \left( \frac{m_t - 1}{n_t - 1} \right) G\left( \frac{m - 2}{m - 1} s_L^2 \right) \right] \right).$$

When  $m_t$  is equal to 1, the mean bycatch rate reduces to the simple mean rate where

$$(4) \quad C_t = \frac{X_t}{n_t},$$

and

$$(5) \quad \text{var}(C_t) = \left( \frac{X_t}{n_t} \right)^2,$$

where  $X_t$  is the total number of animals (dead) taken in the stratum.

The  $C_t$  calculated above gives the mean number of animals killed per vessel trip in the observed trips. To calculate an annual mortality, these rates are multiplied by the prorated number of trips in an analytical stratum from the logbook data.

## Results and Discussion:

Interactions with protected species in the shark drift gillnet fishery are a rare event. Despite very high observer coverage all estimates of bycatch are very imprecise, and this reflects primarily the low frequency of these events. The highest bycatch rates and the majority of observed interactions with all species occurred during the “right whale” season between January and March and in the southern Florida stratum (Table 1, Table 2). Interactions with bottlenose dolphins exclusively resulted in mortalities. The two sea turtle species were more typically released alive (Table 2). The large number of interactions with leatherback turtles during 2001 seems to have been an anomalous event, perhaps associated with changes in environmental conditions.

The observer effort in this fishery has been largely concentrated during the right whale season and in the southern Florida stratum (Table 3). During 2001, the number of observed trips in this region exceeded the reported effort, and it was assumed that the observed effort accounted for 100% of the true fishing effort. In addition, there is a small amount of effort near Key West, Florida prosecuted by a single vessel, but there have been no observed interactions with protected species in this region. In recent years, there has been an increasing amount of observer coverage during the non-Right Whale period (April-November) in the central Florida region where the majority of fishery effort is reported to occur (Table 3). The increasing observer coverage in central Florida allows direct estimation of total bycatch in this region, which was not possible in previous analyses (Garrison, 2001).

In recent years, the gillnet vessels have employed “strike” netting (Table 3) where a additional vessels are used to encircle a school of sharks in the net as opposed to allowing the net to passively drift in an area for a long period of time. The soak time in strike sets is much lower than that in drift sets, fishing operations occur during the day, and one would expect a much lower bycatch and incidental take rate due to the targeted nature of the effort. The proportion of strike sets in this fishery has been increasing in recent years, with a concomitant increase in observer coverage of these sets (Table 3, Carlson and Lee, 2000; Carlson and Baremore, 2002a). There are generally very low catches of non-target fish species in strike sets, and there has never been an observed interaction with a marine mammal or turtle. It is impossible to distinguish strike netting trips from drift netting trips in the fisheries logbook data. Therefore, the extent to which reported effort includes both drift and strike sets is unknown.

Estimates of the total mortality of marine mammal and turtle species are shown in Table 4. The primary source of uncertainty in these estimates is the reported effort. The shark gillnet fishery is poorly defined, and there is a large amount of gillnet effort that lands sharks which is not included in the current estimate. In addition, there is apparently a high degree of underreporting to the fishing vessel logbook program. Several vessels in the fishery that have had observed trips have not reported fishing effort to the logbook program during the last 2 years. It is also difficult to distinguish between trips where these vessels are targeting sharks from those where they are targeting other species. Thus, the actual level of shark drift gillnet effort by these vessels is unknown and is likely underestimated.

However, it is unlikely that this underreported fishing effort would impart a significant negative bias in the bycatch and mortality estimates. Based upon relatively high observer coverage in the last 2 years, the estimated bycatch rates outside of the southern Florida stratum and the right whale season are very low. During the period when bycatch does occur, observer effort is consistently high and approaches 100% of the true fishing effort. Thus, the observed interactions with protected resources during this period likely encompass the vast majority of such interactions that occur in any given year. Improved reporting of fishing effort would greatly improve the level of confidence in the estimated mortality rates.

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Table 1. Observed takes of marine mammals by observed shark gillnet vessels.

<b>Bottlenose Dolphin</b>									
Year	Landing Date	Number Dead	Number Released Alive	Latitude	Longitude	Net Length (feet)	Mesh Size (inches)	Depth (feet)	Soak Time (hours)
1999	26-Feb	1	0	27.30	-80.10	7200	6-10	55	10.6
1999	11-March	3	0	27.34	-80.17	7000	6-10	35-50	9.0
2000	20-Feb	1	0	27.65	-80.27	7500	5.5-8	45	6.4
2001	14-Feb	1	0	27.48	-80.19	7800	4-10	35	8.4
2001	23-Feb	1	0	27.39	-80.14	7200	6-9	40	18.2
2001	1-March	1	0	27.69	-80.29	5400	5-8	35	8.9
2001	1-March	1	0	27.51	-80.22	6000	4-10	35	9.3
2002	2-July	1	0	28.75	-80.49	6900	5	50	8.3
<b>Spotted Dolphin</b>									
Year	Landing Date	Number Dead	Number Released Alive	Latitude	Longitude	Net Length (feet)	Mesh Size (inches)	Depth (feet)	Soak Time (hours)
2000	10-Feb	0	1	27.28	-80.10	6000	6-10	55	1.4
2001	16-Feb	0	2	27.33	-80.14	6900	7-10	3.5	2.3
2001	27-Feb	1	0	27.3	-80.14	6000	4-10	35	10.6

Table 2. Observed takes of marine turtles by observed shark gillnet vessels

<b>Leatherback Turtle</b>									
Year	Landing Date	Number Dead	Number Released Alive	Latitude	Longitude	Net Length (feet)	Mesh Size (inches)	Depth (feet)	Soak Time (hours)
2001	1-Feb	0	2	27.40	-80.19	7200	6-9	40	6.4
2001	2-Feb	0	1	27.82	-80.34	2100	5-9	45	5.3
2001	7-Feb	0	1	27.39	-80.15	7000	7-10	35	7.8
2001	14-Feb	0	2	27.48	-80.19	7800	4-10	35	8.4
2001	15-Feb	0	1	27.63	-80.24	7500	5-9	35	9.8
2001	22-Feb	0	2	27.22	-80.02	7200	6-9	40	10.0
2001	23-Feb	0	1	27.39	-80.14	7200	6-9	40	18.2
2001	27-Feb	0	1	27.84	-80.30	5400	5-8	35	2.4
2001	27-Feb	2	0	27.32	-80.14	6000	4-10	35	10.6
2001	1-March	0	1	27.69	-80.29	5400	5-8	35	8.9
2002	21-Jan	0	1	27.26	-80.09	7500	5-8	35	6.8
2002	19-Feb	0	1	27.38	-80.13	5400	5-10	30	9.6
<b>Loggerhead Turtle</b>									
Year	Landing Date	Number Dead	Number Released Alive	Latitude	Longitude	Net Length (feet)	Mesh Size (inches)	Depth (feet)	Soak Time (hours)
2000	1-Feb	1	0	27.27	-80.09	9000	10	30	10.5
2000	9-August	0	1	31.10	-81.29	2450	5-10	10	3.5
2001	1-March	0	1	27.69	-80.25	7500	5-8	35	5.8
2002	9-Feb	0	1	27.31	-80.11	6000	5-10	30	8.5

Table 3. Shark gillnet reported effort and observer coverage by analytical strata.

<b>Right Whale Season: November 15 – March 30 (RW)</b>				
Year	Reported Effort	Trips Observed	Drift Sets Observed	Strike Sets Observed
<i>Key West (KW)</i>				
1999	9	0	0	0
2000	11	4	9	0
2001	8	4	8	0
2002	13	5	13	0
<i>South Florida (SFL)</i>				
1999	62	20	20	2
2000	61	31	31	12
2001	44	57	57	12
2002	34	20	20	24
<b>Non-Right Whale Season: April 1 – November 14 (NRW)</b>				
Year	Reported Effort	Trips Observed	Drift Sets Observed	Strike Sets Observed
<i>South Florida (SFL)</i>				
1999	33	1	1	0
2000	15	0	0	0
2001	21	6	6	0
2002	4	0	0	0
<i>Central Florida (CFL)</i>				
1999	255	11	11	0
2000	127	0	0	3
2001	115	12	12	5
2002	100	15	15	14
<i>Georgia (GA)</i>				
1999	68	20	20	0
2000	65	15	15	0
2001	56	4	4	0
2002	70	14	14	0



Table 4. Incidental take and mortality estimates for protected resources in the shark drift gillnet fishery by analytical strata. Only strata with non-zero bycatch rates are shown for each species. Mortality and live take estimates indicate the total estimated number of animals killed or taken and released alive in the given stratum and year. During the right whale season in 2001, 100% observer coverage was achieved in the south Florida stratum, thus the total bycatch is assumed to be equal to the observed number of incidental takes.

<b>Bottlenose Dolphin (<i>Tursiops truncatus</i>)</b>						
Year	Season	Area	Mortality Estimate	Mortality %CV	Live Take Estimate	Live Take %CV
1999	RW	SFL	12.4	77.7	0	-
2000	RW	SFL	2.0	100	0	-
2001	RW	SFL	4.0	0	0	-
2002	NRW	CFL	6.7	100	0	-
<b>Atlantic Spotted Dolphin (<i>Stenella frontalis</i>)</b>						
2000	RW	SFL	0	-	2.0	100
2001	RW	SFL	1.0	0	1.0	0
<b>Leatherback Turtle (<i>Dermochyles coriacea</i>)</b>						
2001	RW	SFL	2.0	0	12.0	0
2002	RW	SFL	0	-	3.4	68.8
<b>Loggerhead Turtle (<i>Caretta caretta</i>)</b>						
2000	NRW	GA	0	-	4.4	100
2000	RW	SFL	1.0	100	0	-
2001	RW	SFL	0	-	1	0
2002	RW	SFL	0	-	1.7	100

Figure 1. Typical locations of observed drift gillnet sets on the Florida and Georgia coasts during the right whale (Nov 15 -Mar) and non-right whale seasons (Apr – Nov 15). Fishery statistical areas are shown.

